Injection-Mining Scheme Optimization of Underground Gas Storage Based on Agent Model

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Abstract

Underground natural gas storage (UNGS) plays a vital role in the peaking adjustment of gas supply. Optimization of UNGS injection-production operations is essential for improving storage efficiency and capacity. This study first establishes and compares nine classical machine learning models such as physical neural network, gradient Boosting, and neural networks for prediction model preference, and finally selects extreme gradient Boosting (XG-Boost) to construct an agent model for predicting well pressure, which replaces the traditional complex mathematical model. Furthermore, a multi-objective optimization model was established after the optimization algorithm was preferred based on the agent model, with the objectives of maximizing the gas injection and extraction volume and minimizing the pressure difference between blocks by using a non-dominated sorting genetic algorithm-III (NSGA-III). We identified cases of injection-mining scheme optimization in the Wen23 large-scale UNGS and excluded substandard samples. By comparing the optimization results to the numerical model empirical scheme, the results indicate that the average differential pressure in each well zone decreased by 2% (33.3 MPa). Simultaneously, the maximum differential pressure between blocks was reduced significantly by 64%. On the other hand, after optimization at the end of gas production, the average well zone pressure increased by 6% (24.1 MPa), while the maximum differential pressure between blocks remained unchanged. This model also shows the merits of extreme conditions for injection mining, with the average value of the mean absolute error (MAE) between the optimized and numerical model schemes being 0.25. It is an effective optimization model that can assist and guide UNGS injection production to improve pressure distribution, gas diffusion range, and storage capacity.

Keywords

Underground Gas Storage, Injection-Mining Scheme, Machine Learning, Agent Model, Optimization Algorithm